

# **Hurricane Imaging Radiometer (HIRAD) Observations in Hurricanes Patricia, Joaquin, and Marty (2015)**

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*Acknowledgements:*

Office of Naval Research

TCI science and forecasting teams

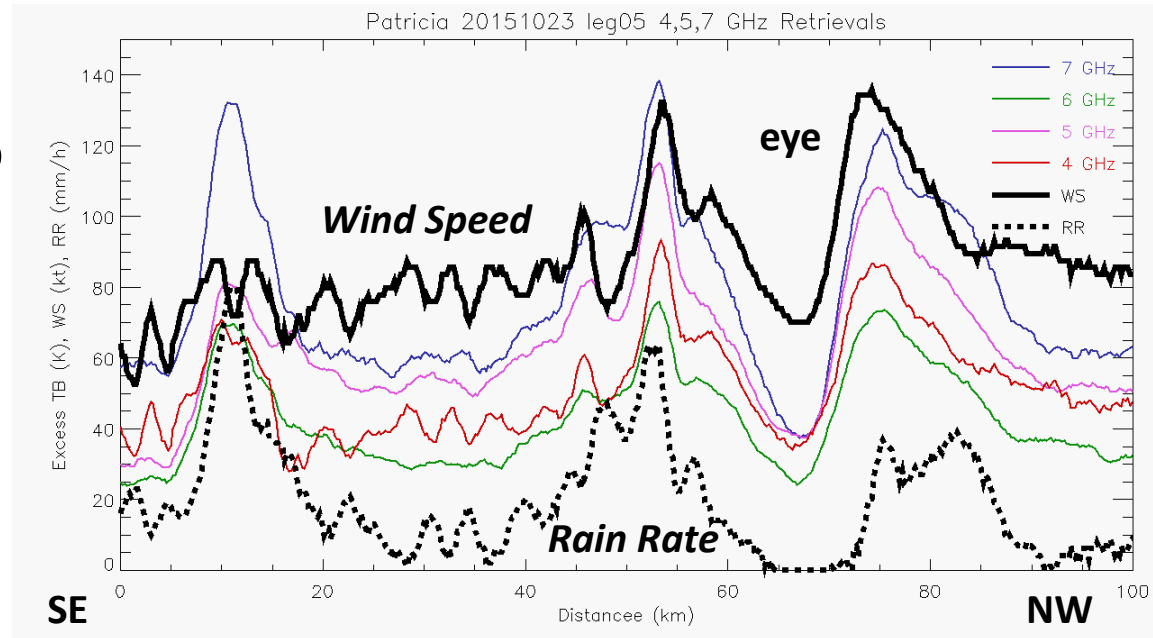
NASA WB-57 pilots and crew – *outstanding support to  
make this field program a success!*

C-band (4, 5, 6, 6.6 GHz)  
radiometer

Retrieval concept similar to  
the operational Stepped  
Frequency Microwave  
Radiometer (SFMR)

**Retrieve Wind Speed and  
Rain Rate over ocean, *but*  
*over a wide swath***

# HIRAD Background



**Rain especially affects  
higher freq channels**

**Wind causes an  
increase in all channels**

C-band frequencies have varying sensitivity to rain but ~equal sensitivity to wind speed (emission from foam on wind-roughened ocean surface)

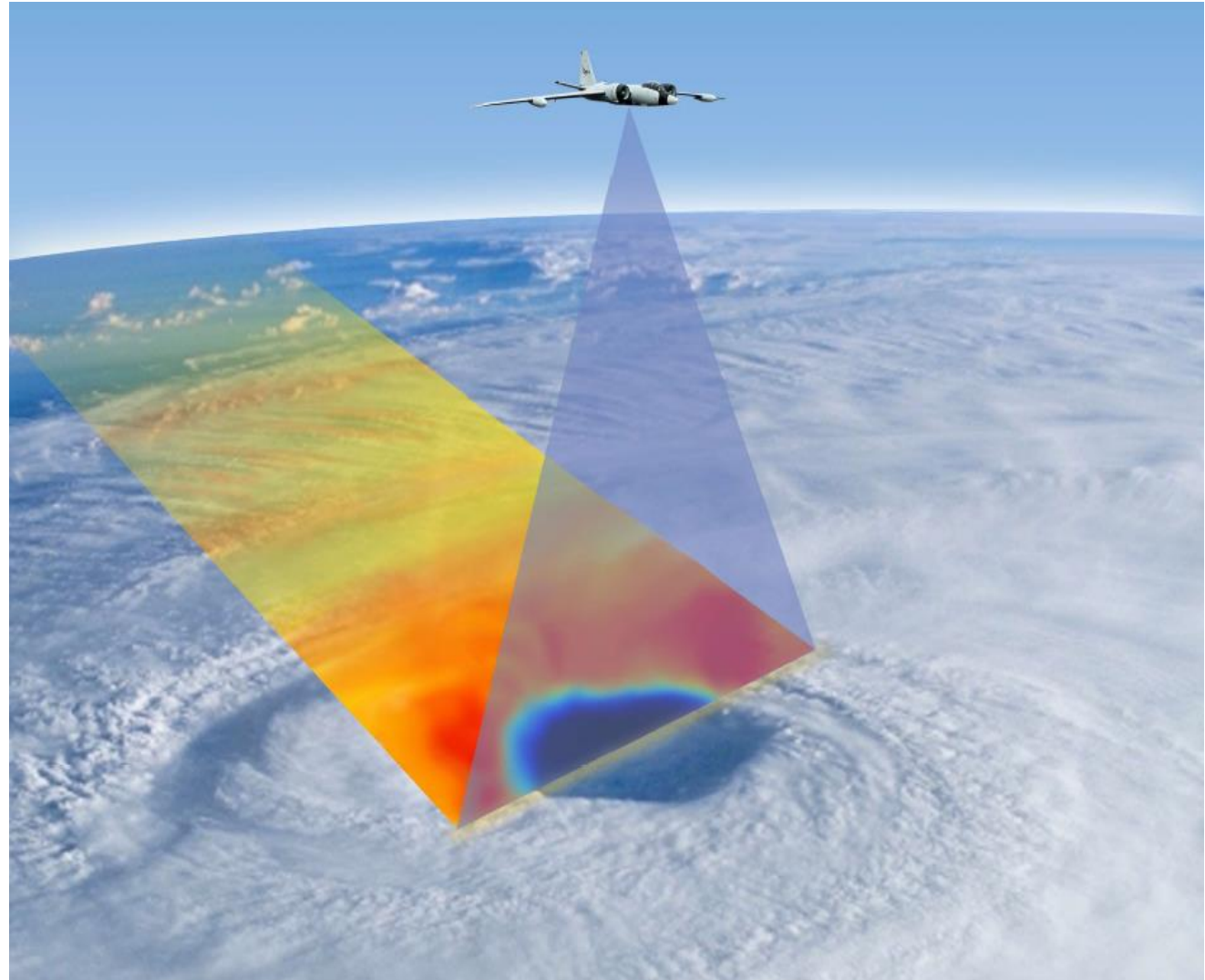
# HIRAD on NASA WB-57

HIRAD flew on WB-57 for NASA HS3 in 2014 and ONR TCI in 2015.

~20 km altitude, looking down on storm

~50-70 km swath width

WB57 also had High Density Dropsonde System (HDSS) in 2015, typically dropping ~70-80 sondes in a flight.



# Tropical Cyclone Intensity Experiment (TCI 2015)

*funded by Office of Naval Research*

NASA WB-57 (JSC) carrying:

**HDSS dropsondes**

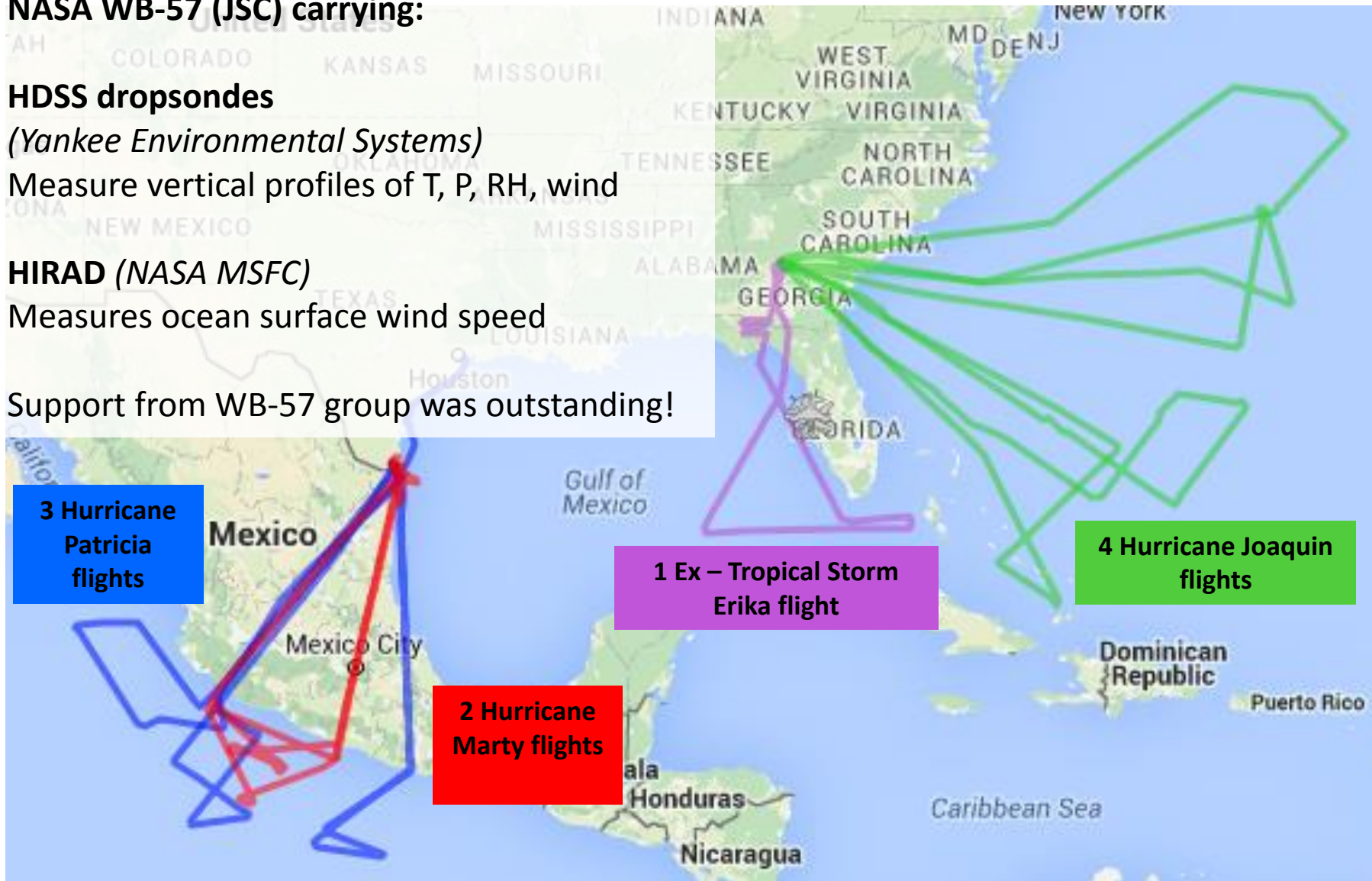
*(Yankee Environmental Systems)*

Measure vertical profiles of T, P, RH, wind

**HIRAD (NASA MSFC)**

Measures ocean surface wind speed

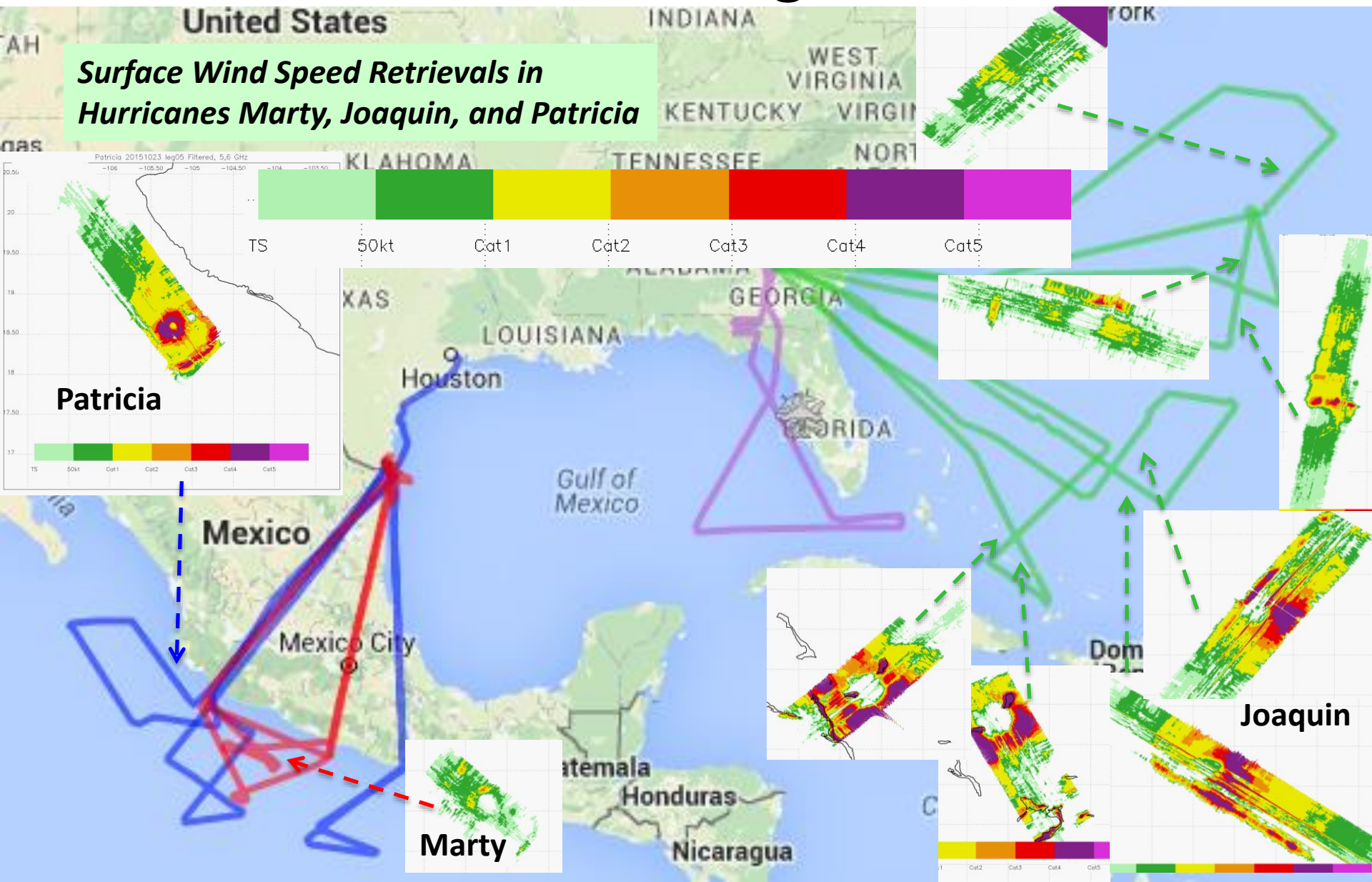
Support from WB-57 group was outstanding!





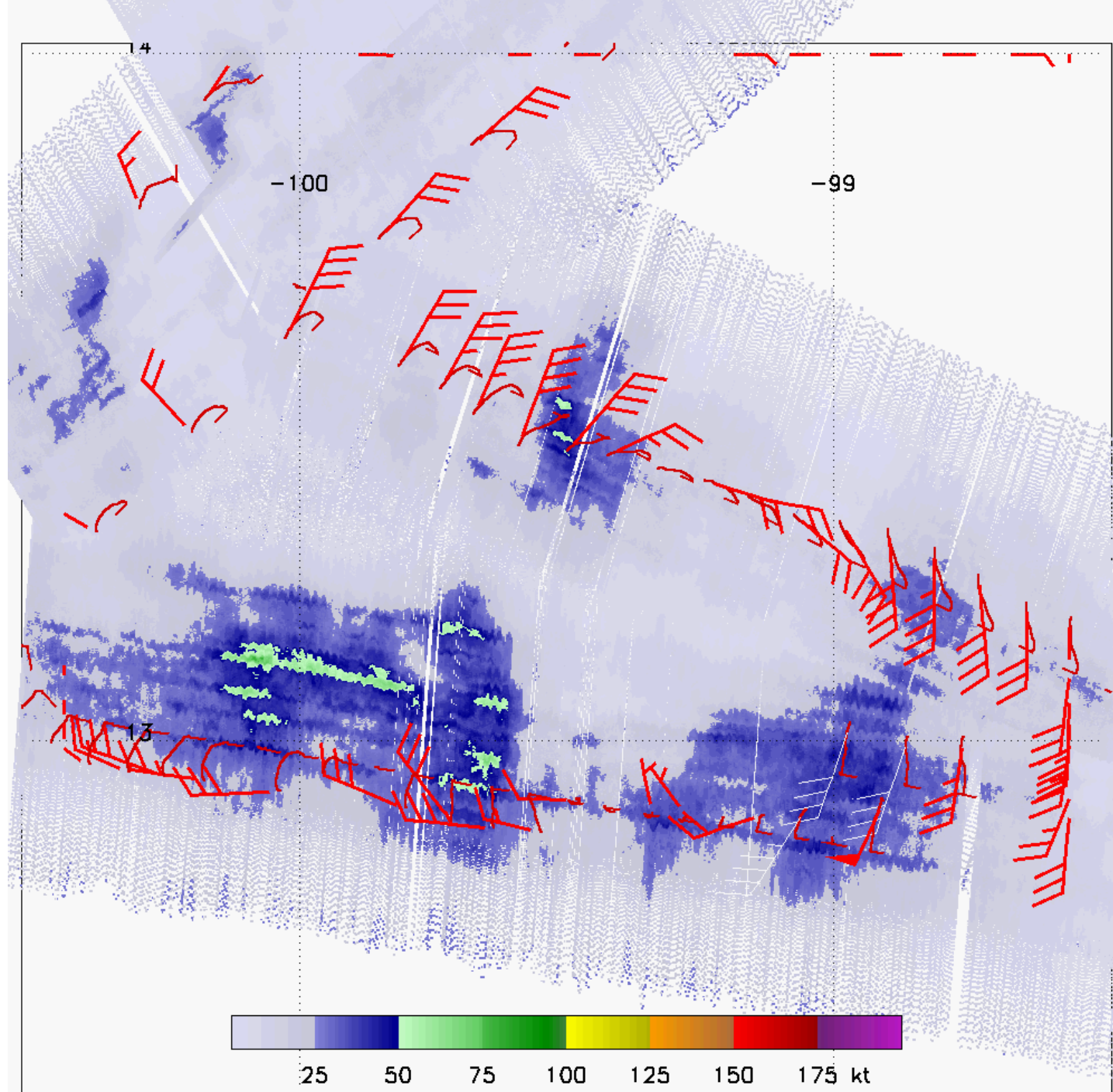
# 2015 Tropical Cyclone Intensity (TCI) Science Flights

*Surface Wind Speed Retrievals in  
Hurricanes Marty, Joaquin, and Patricia*



# Hurricane Patricia 21 Oct 2015

Winds mostly  
40 kt and less  
from  
dropsondes –  
not much for  
HIRAD to see

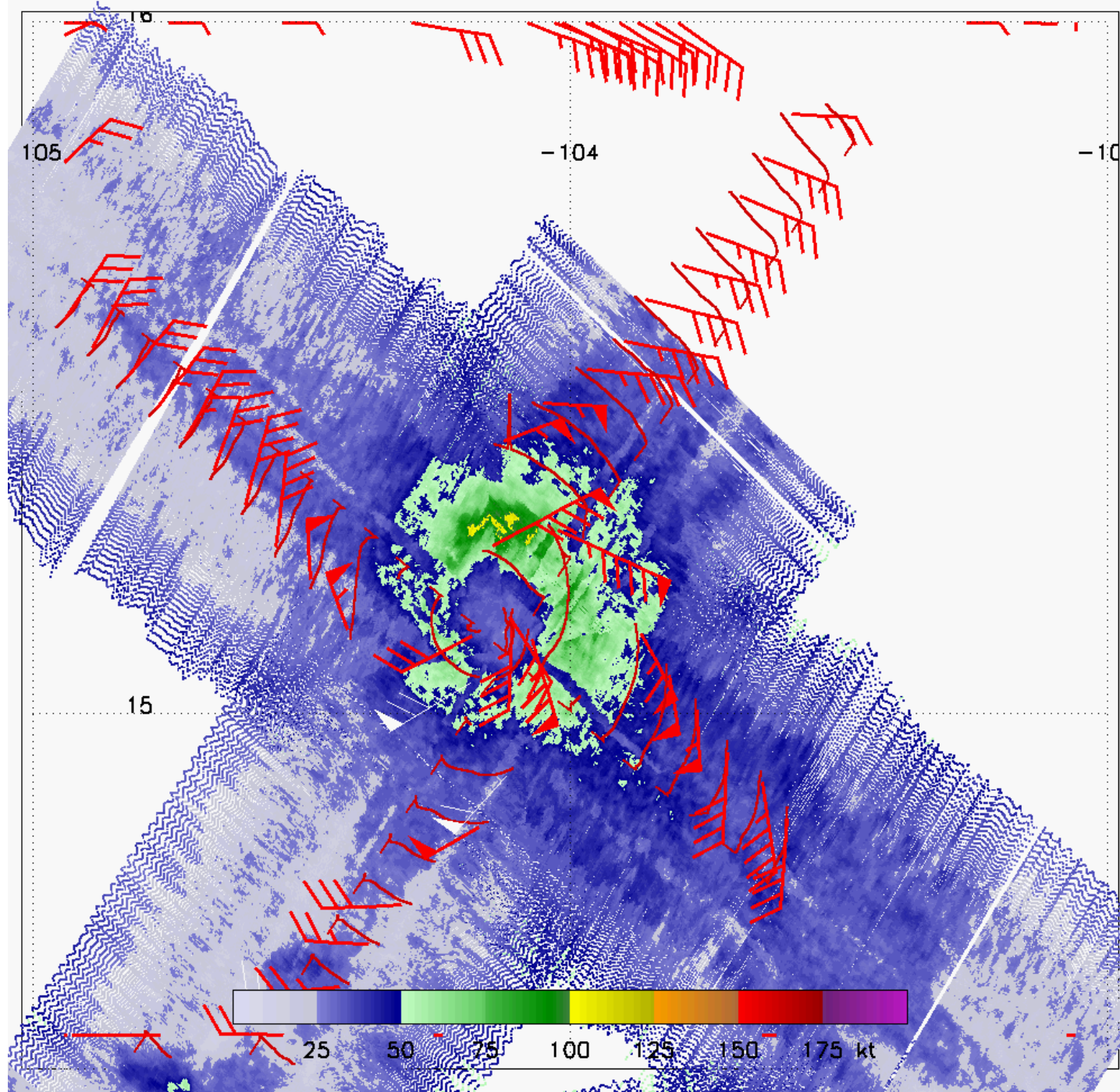




# Hurricane Patricia

22 Oct 2015

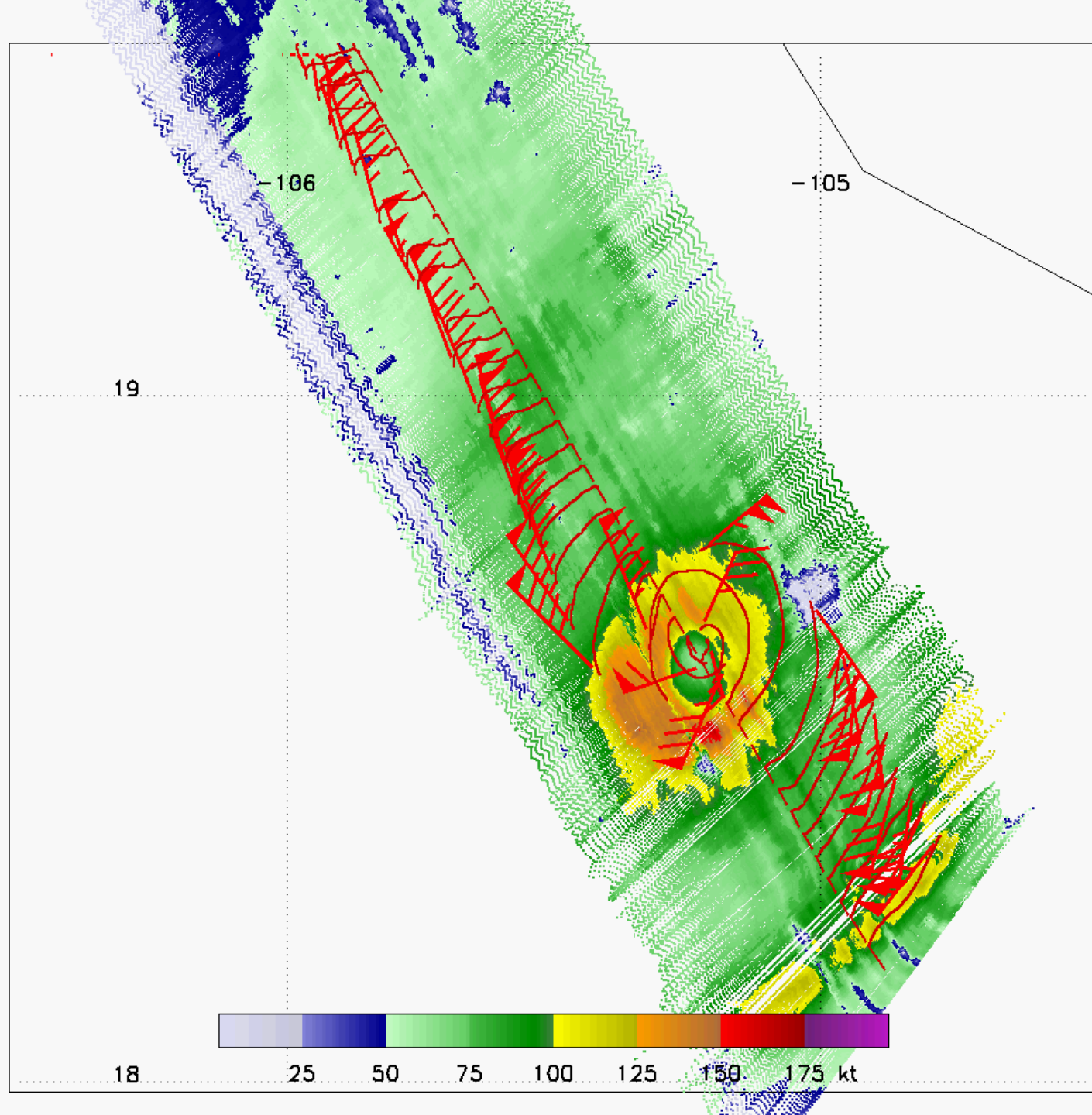
Wind speed  
retrieval  
(work in  
progress;  
biased low)  
compared  
with HDSS  
dropsonde  
near surface  
winds



# Hurricane Patricia

**23 Oct 2015  
20:00 UTC**

Wind speed  
retrieval  
(work in  
progress)  
compared  
with HDSS  
dropsonde  
near surface  
winds



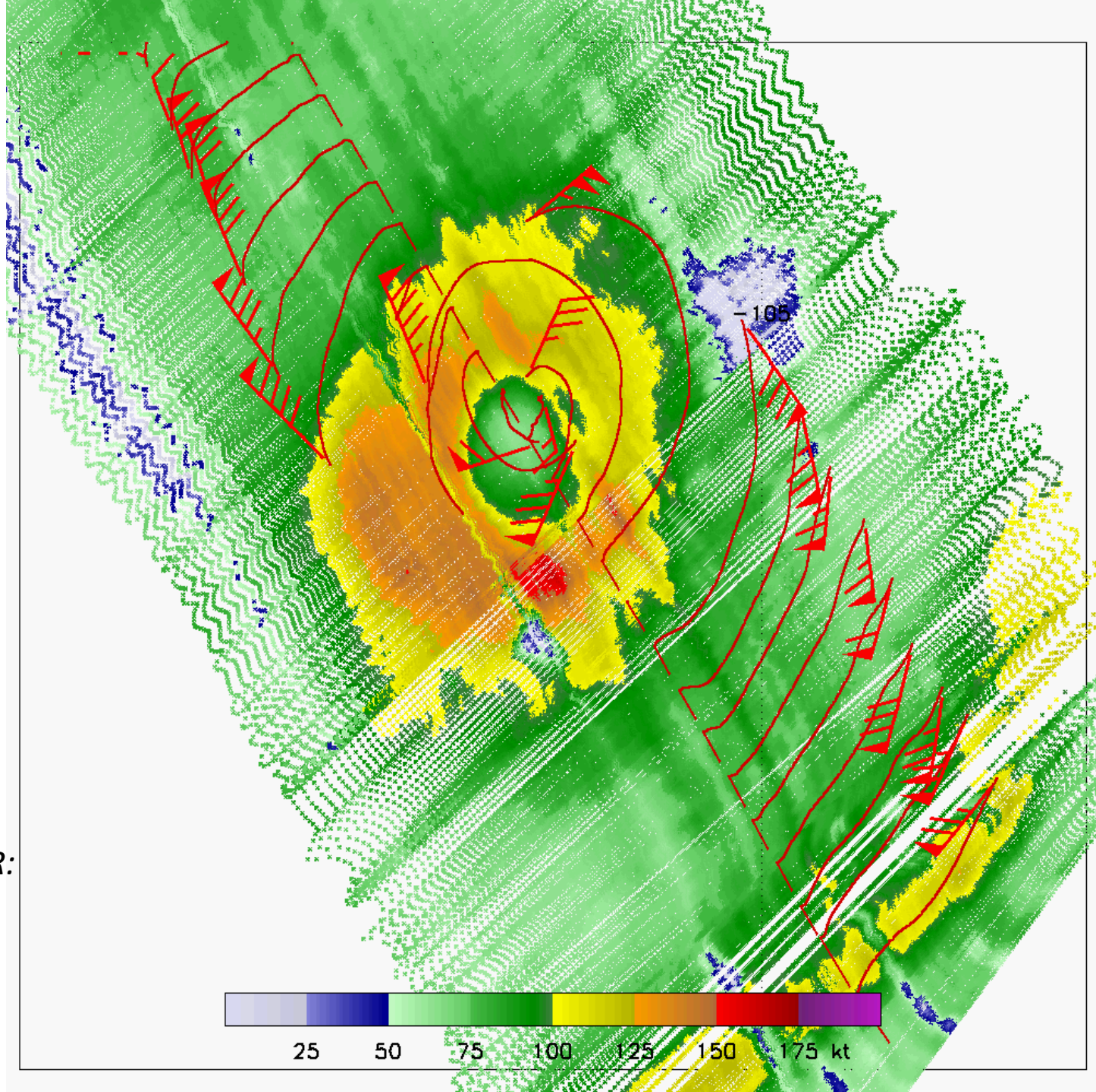


# Hurricane Patricia

**23 Oct 2015  
20:00 UTC**

Peak in this  
retrieval is  
165 kt, but  
we're not  
confident in  
some aspects  
of these  
retrievals yet

*For reference, SFMR:  
180 kt 1733 UTC  
131 kt 2033 UTC*

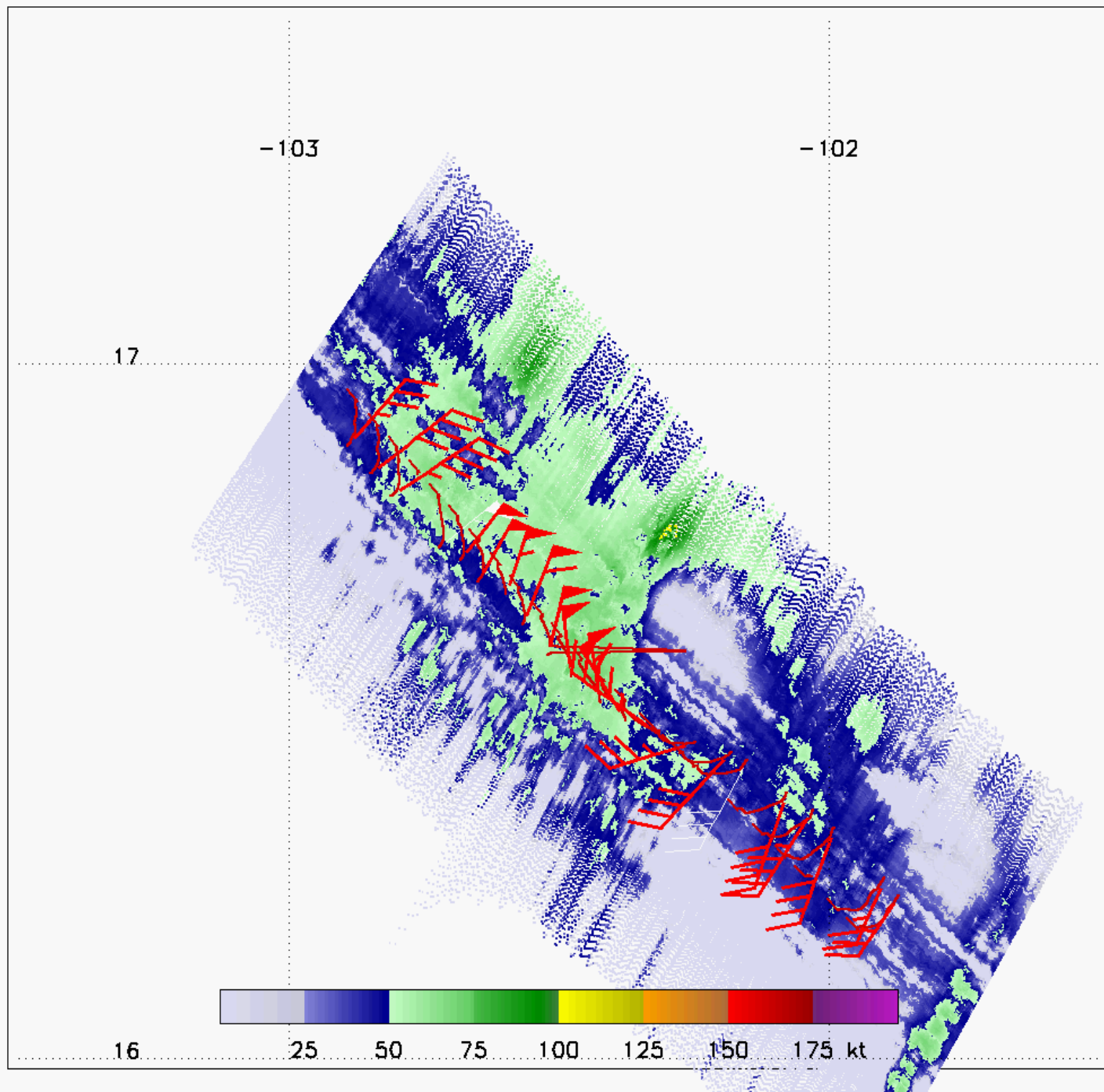


# Hurricane Marty

28 Sep 2015

19:25 UTC

Wind speed  
retrieval  
(work in  
progress)  
compared  
with HDSS  
dropsonde  
near surface  
winds





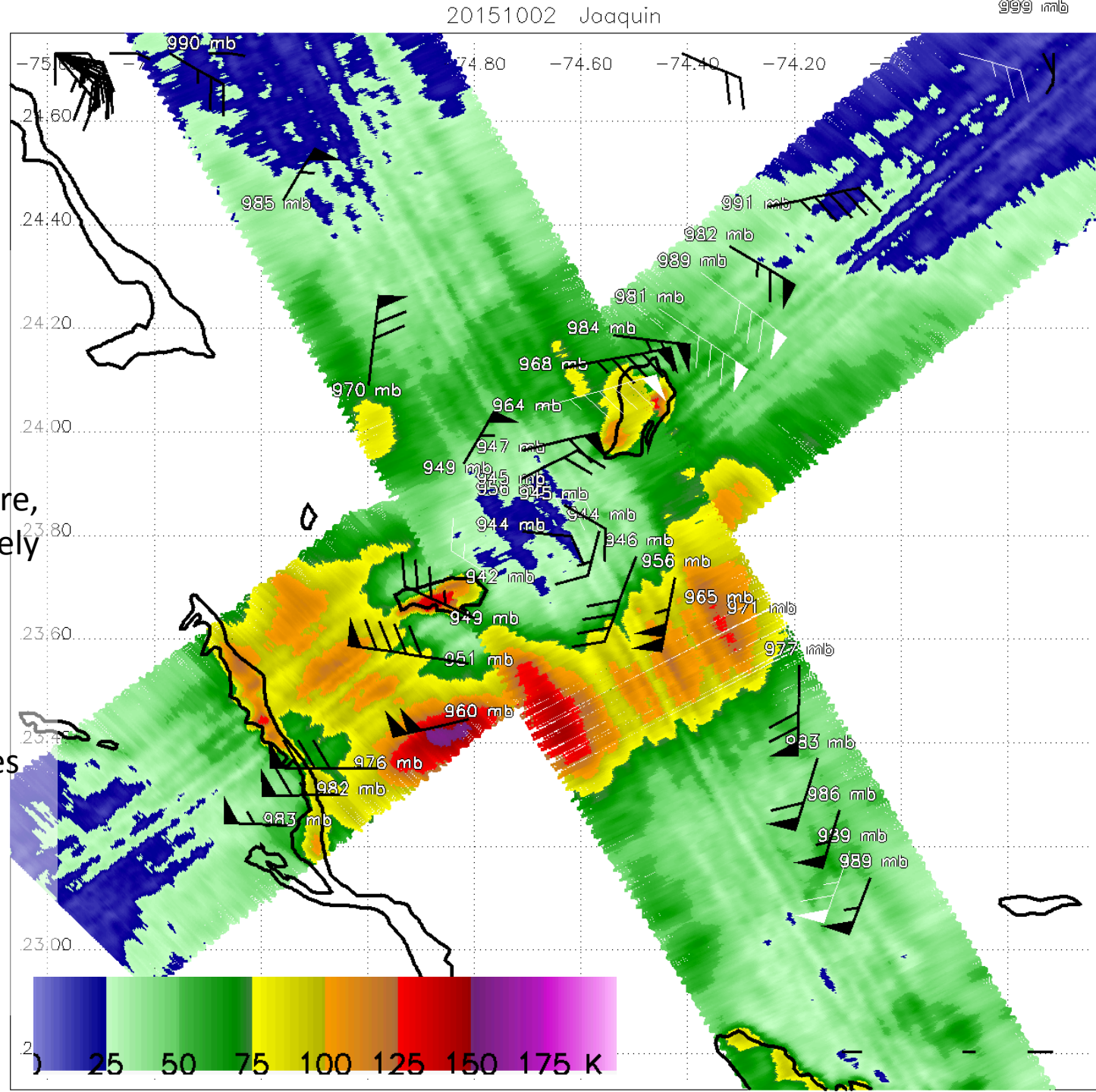
# Hurricane Joaquin 02 Oct 2015

Preliminary HIRAD 6.6  
GHz Excess TB, rough  
calibration.

WB-57 dropsondes  
support 942 mb pressure,  
105 kt surface wind, likely  
missed max wind

Wind Barbs are surface  
wind speed estimates  
from WB-57 dropsondes

*White barbs are estimates from sondes that failed higher than 150 m above surface*





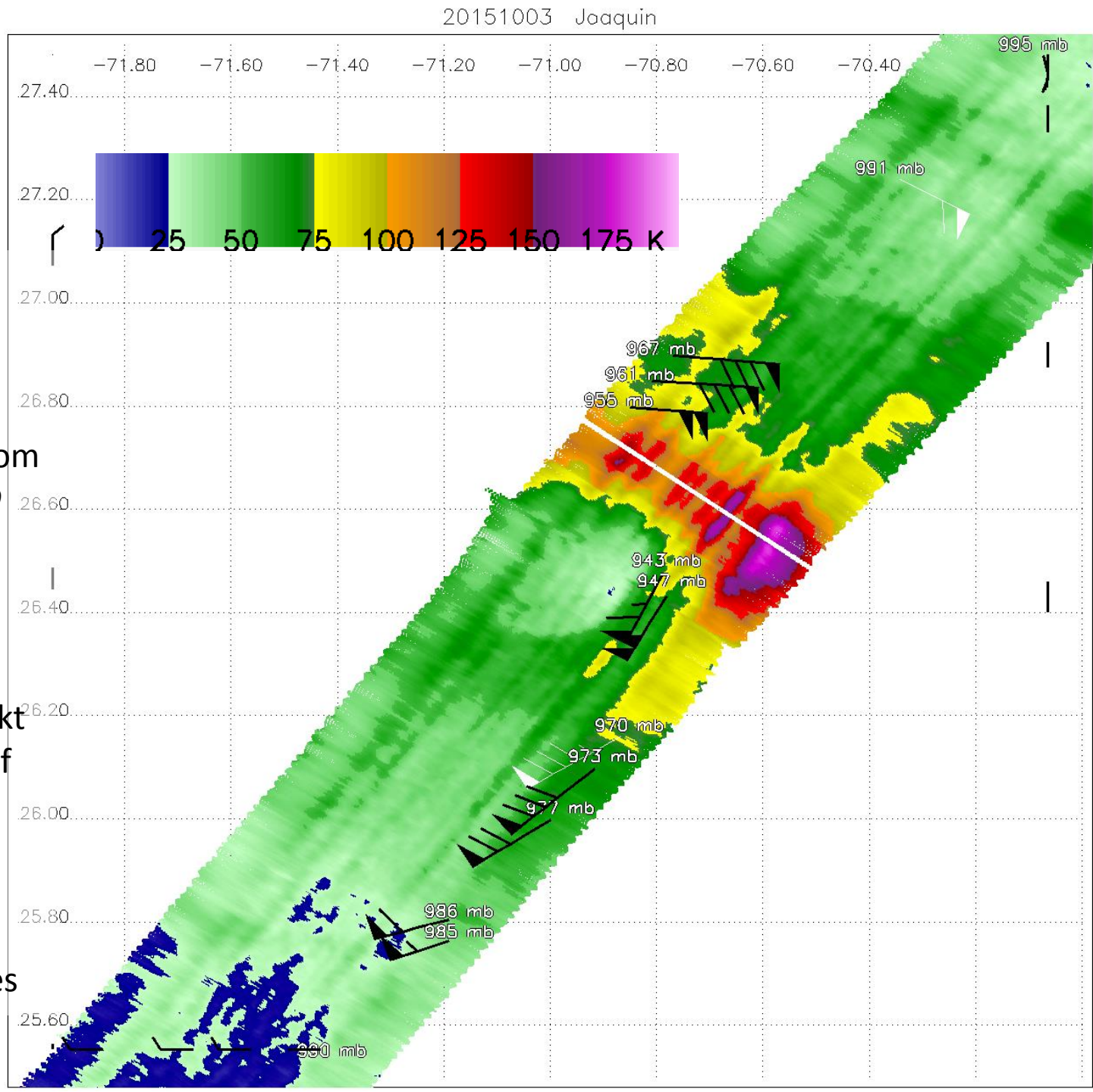
# Hurricane Joaquin 03 Oct 2015

Preliminary HIRAD 6.6  
GHz Excess TB, rough  
calibration.

100 kt surface winds from  
dropsondes, but *HIRAD*  
*shows those sondes*  
*missed the region of*  
*strongest winds*

NHC estimate was 130 kt  
during this flight, end of  
RI period

Wind Barbs are surface  
wind speed estimates  
from WB-57 dropsondes



# Summary

- Initial retrievals realistically depict the *horizontal structure* of the hurricanes (Marty 15, Joaquin 15, Patricia 15)
- But quantitative aspects of the calibration and retrievals need more work
- Depicts remarkable development of Hurricane Patricia from 50-kt TS on Oct 21, ~100 kt Hurr on Oct 22, rapidly *weakening* cat 5 on Oct 23 (~20:00 UTC)
- Patricia small core size fits within a single HIRAD swath
- Joaquin was larger, have to piece together multiple passes
- Lots of dropsonde data available for comparisons, we've only qualitatively looked at that so far

# Future / Ongoing Work

- Filtering the scan-position-dependent biases (promising, but imperfect)
- Improve relative calibrations between the channels, in order to improve the retrievals
- Long term, hope to add wind *direction* in a future instrument with greater sensitivity, full polarization